APRIL 23, 1990
CHEMICAL & ENGINEERING

NEWS

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05111796C090 9 K AR6817SL 0643
CONGRESSIONAL INFO SERV-SRI
SRI ACQUISITIONS
4520 EAST WEST HWY SUITE 800
BETHESDA MD 20814-3389

AEROSOLS

Public attitudes, regulation push product innovation

Page 35

Volume 68, Number 17
CENEAR 68 (17) 1–76
ISSN 0009-2347

CHEMICAL & ENGINEERING NEWS

APRIL 23, 1990

News of the Week

■ **White House-sponsored conference on global-change attacked by participants as too narrow, stifling discussion of action to take.** Page 4

■ **White House actions continuing U.S. boycott of UNESCO, restoring funding to international research center, show science adviser office still not steering Administration toward a coordinated science policy.** Page 5

■ **Two physical organic chemists, William von Eggers Doering and John D. Roberts, win this year's Welch Award in Chemistry.** Page 5

■ **Report urges actions to deal with threat to human health posed by toxic substances in Great Lakes.** Page 5

■ **Rhône-Poulenc Ag Co. will voluntarily halt sales of aldicarb for use on potatoes.** Page 6

■ **Early first-quarter reports indicate chemical earnings may not be so bad as analysts had feared.** Page 6

Cover: Photo courtesy of Du Pont

Letters 2

Concentrates

Business 7
Government 15
Science/Technology 18

The Departments

Software/Database Update 24
Awards 53
People 53
Meetings 56
Newscripts 76

Business

Hercules works through current series of write-downs and reorganizations while evolving plans for its future. **Page 9**

Southeast Asia is becoming new trade area for U.S., according to report by Federal Reserve Bank of Chicago economist. **Page 12**

China's efforts to further expand its petrochemical industry are response to the country's growing fuel needs. **Page 14**

Government

Presidential science adviser D. Allan Bromley discusses plight of individual investigator, declining value of R&D dollars. **Page 16**

House Energy & Commerce Committee moves quickly to approve clean air bill that reflects series of compromises. **Page 17**

Science/Technology

In generating new technology to meet demands of economic expansion, Air Products exemplifies new wave of multinational firms. **Page 20**

Priestley Medal Address

Cornell University's Roald Hoffmann speaks of chemistry and democracy in response to environmental concerns. **Page 25**

Books

The merging of science and finance is traced in Robert Teitelman's book, "Gene Dreams"; "Is Science Necessary?: Essays on Science and Scientists" offers some insights into thoughts of Nobel Laureate Max F. Perutz. **Page 30**

Product Report

Growth in aerosol production has slowed because of rising pressures from the public and numerous regulations, spurring new packaging forms and other aerosol production innovation. **Page 35**

Chemical & Engineering News
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Published by
AMERICAN CHEMICAL SOCIETY
(202) 872-4600; TDD (202) 872-8733
John K Crum, Executive Director
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Subscription Rates 1990. Printed editions: nonmembers U.S. 1 yr. $60, 2 yr. $108, outside U.S. 1 yr. $93, 2 yr. $174. Air freight rates available on request. Rates above do not apply to nonmember subscribers in Japan, who must enter subscription orders with Maruzen Co. Ltd., 3-10 Nihonbashi 2-chome, Chuo-ku, Tokyo 103, Japan. Tel: (03) 272-7211. Single copies: Current $9.00. Rates for back issues and volumes are available from Microforms & Back Issues Office, ACS, 1155—16th St., N.W., Washington, D.C. 20036. Back and current issues available on microfilm and microfiche. Rates on request from Microform Program, ACS.

Chemical & Engineering News (ISSN 0009-2347) is published weekly except for the last week in December by the American Chemical Society at 1155—16th St., N.W., Washington, D.C. 20036. Second-class postage paid at Washington, D.C., and additional mailing offices. POSTMASTER: Send address changes to Chemical & Engineering News, Membership & Subscription Services, P.O. Box 3337, Columbus, Ohio 43210. ACS assumes no responsibility for the statements and opinions advanced by the contributors to its publications.

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LETTERS

CHEMICAL SAFETY

Piranha solution explosion

SIR: We wish to report two violent explosions experienced with a sample of "piranha solution" used routinely in many laboratories to clean badly soiled glass frits and other surfaces.

At Berkeley an explosion occurred in a bottle of this mixture that had been stored for several days. In this case, the solution was prepared by carefully mixing approximately 150 mL concentrated sulfuric acid with 150 mL 30% hydrogen peroxide with cooling over 30 minutes. No difficulty was experienced during the preparation, and no incidents were encountered after the preparation while the solution was allowed to stand (we believe only loosely capped) in a fume hood. However, one week after the solution was prepared it detonated spontaneously in the hood, destroying the glass container in which it was stored, as well as other bottles of chemicals stored in the hood.

The other incident occurred several years ago at Cornell University. A graduate student was cleaning glass frits by a standard procedure of drawing small portions (about 20 mL) of a freshly prepared mixture of concentrated H_2SO_4 and 30% H_2O_2 through the frits by applying vacuum suction. This operation was eventually followed by washing with deionized water and finally acetone (keeping the different liquids separate). On this particular occasion, a violent explosion occurred, which shattered the heavy walled filter flask and caused multiple cuts in the face, chest, and forearms of the student. A partially lowered hood sash and appropriate clothing (safety glasses, lab coat, and heavy rubber gloves) provided some protection, but could not prevent the infliction of serious injuries. Subsequent questioning of the student led us to believe that inadvertent mixing of the highly oxidizing H_2SO_4/H_2O_2 mixture with an acetone residue (amounts unknown) was the cause of this accident.

At Berkeley, it is possible that an oxidizable organic material was somehow added to the bottle in which the solution was stored, or that the top of the container was inadvertently tightened. However, to the best of our knowledge neither of these things occurred. Furthermore, the force of the detonation makes it seem likely to us that it was due to a chemical reaction rather than simply to the buildup of pressure in the container. In any case, we feel that the most prudent interpretation of these events is that sulfuric acid/hydrogen peroxide mixtures are susceptible to spontaneous and unpredictable chemical detonation. Warnings in the literature that these solutions be handled carefully should therefore be taken especially seriously. We recommend that this mixture not be stored for any length of time, and if possible not be prepared or used at all.

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Having the ultimate secret

SIR: In the review of Jeremy Bernstein's book about high-energy physics (C&EN, Jan. 22, page 27), astrophysicist Richard C. Henry claims, "We chemists and astronomers already have in our hands the ultimate secret of the universe, for what it's worth. Certainly time did not exist before you became conscious, and it will end when you die. But most of us do not have the ego for this."

Ego, using its colloquial definition, has long been involved in pronouncements like these. About having the ultimate secret, John Heywood in the year 1598 remarked, "Every cocke is proud of his own dunghill." As for time existing only in the mind of man, are we to believe a rock ceases to decay progressively with time if we are not there to watch it? Samuel Johnson in 1793, when challenged by Bishop Berkeley's "ingenious sophistry" that matter exists only in the mind, "answered, striking his foot with mighty force against a large stone, till he rebounded from it—'I refute it thus.'"

Could it be that our earnest practitioners of high technology, having ripped off the lid of Pandora's box of nuclear energy, are at risk of becoming as unhinged as the box?

Miles H. Robinson
Santa Barbara, Calif.

Time to help

SIR: Wouldn't it be nice if Lewis J. Schupp's letter (C&EN, March 5, page 3) commenting that he is troubled by what he doesn't see happening in U.S. science and math education caused large numbers of scientists, educators, parents, and others to demand action—not more study and talk? This action requires the

More recently, Hollingsworth emphasized Hercules' commitment to developing its new technologies businesses such as advanced materials and liquid molding resins when he told C&EN it is "overwhelmingly important to address enterprise businesses—the longer term businesses that you get little immediate credit for." While he acknowledges his obligation to Hercules' public ownership base in terms of delivering immediate results, he also feels the stronger pull in guaranteeing his company a strong business and technology position in the years ahead.

As part of the effort to succeed, Hollingsworth points to Hercules' recent reorganization into eight business units. It is, he says, expected to bring about "profound changes from an organizational and cultural perspective," in the way Hercules runs its emerging businesses as well as its core businesses. The change, adds Hollingsworth, is meant to make the units "more market oriented, customer oriented and quality oriented." The move most of all should "create a greater sense of accountability among our people," and is ultimately "designed to take advantage of global opportunities."

Return on stockholders' equity should again approach 14 to 15%, says Hollingsworth. "It's in the cards. It's part of our business plan over the next few years," he says.

The problem for Hercules and Hollingsworth is to get more out of the company's existing core businesses so that they will contribute solidly to the bottom line as well as support emerging technology businesses. But that is more easily said than done. Hercules has had to shore up its core businesses in 1989 to the detriment of the bottom line: A new pale-wood rosin extraction process to update an 80-year-old line was delayed in coming on stream, and a failure to invest in wider web packaging film machinery lost tobacco industry packaging markets that new investments won't recoup until the first quarter of 1991.

Although some core business problems have been addressed, others remain. Hollingsworth believes he must better balance Hercules' portfolio of aerospace, chemical, and advanced materials businesses. He has succeeded to some extent, he believes, in rebuilding the chemical core with the purchase of Henkel's 50% interest in Aqualon.

Admittedly, the rocket motor propulsion aerospace business has done poorly in 1989. Hercules had to absorb the cost of rebuilding part of its Bacchus facility in Utah after a fire, but changes in government procurement procedures required Hercules, along with other defense industry contractors, to put more money into initial product development. The $323 million charge against earnings in 1989 was meant to put these difficulties behind Hercules.

The charges are expected to put Hercules' aerospace business on a more balanced footing vis-à-vis Hercules' chemical and advanced materials business, says Hollingsworth. Now that most of the huge investment in developing its aerospace propulsion business is out of the way, aerospace should figure less prominently in the company's capital outlays. Hollingsworth does acknowledge that aerospace will still be vulnerable to U.S. Congressional decisions on funding military and National Aeronautics & Space Administration rocket ventures.

To help balance large rocket ventures and the large losses they may engender, Hercules, in November 1988, bought a 20% equity in Orbital Sciences Corp. and is involved with that company in developing a low-cost commercial launch system for small satellites. The recent success Orbital Sciences had in launching a three-stage rocket from the wing of a B-52 bomber with a lightweight military payload bodes well for future commercial developments.

"We know advanced materials are not going to be immediately rewarding," says Hollingsworth. And while Metton liquid molding resins and other ventures are just developing—and while carbon fibers are showing a profit—Hercules will continue to support them. But the company's goal is to get its core portfolio of chemical and aerospace businesses in good enough order to finance its ventures in liquid molding resins, flavor and food ingredients, and other new technologies, says Hollingsworth. □

Southeast Asia seen as new U.S. trade area

The political changes taking place in Eastern Europe have focused some attention on the immediate future of U.S. trade with the region. But whatever changes in trading patterns may result from this "new market," they will only add to some substantial changes U.S. trade has already undergone between 1970 and 1988. Among these are a great rise in imports and exports in general and a shift of trade to the Pacific, particularly to Southeast Asia.

A brief analysis of the recent shifts in U.S. trade and the possibilities of additional shifts because of a number of European economic and political trends has been made by Jack L. Hervey, senior economist at the Federal Reserve Bank of Chicago. The current state of affairs is the result of events in the late 1960s, when the European Community and the European Free Trade Association were formed. At the same time, Japan was displaying an economic growth of 15% per year and the Kennedy Administration's round of tariff negotiations was drastically cutting tariffs. When this economic activity began, the U.S. dollar and investment abroad dominated international exchange. According to Hervey, the net effects of these events were elimination of the U.S. trade surplus and a shift of the U.S. trade balance into negative territory.

The dollar was devalued in 1972 and again in 1973. The Organization of Petroleum Exporting Countries quadrupled oil prices in 1973. Large quantities of dollars accumulated by Arab nations were recycled to Latin America and Southeast Asia. During the 1970s, U.S. exports increased by fivefold but its imports increased by sixfold, and the annual U.S. trade deficit averaged $26 billion. All of these events, says Hervey, set the stage for the new trade era of the 1980s.

The patterns of U.S. trade have changed with respect to geography and commodities. Canada is still the largest single trading nation for the U.S. However, Hervey says, its position in the U.S. trade picture is not so secure as it once was. In addition,

in recent years Western Europe has become less prominent as a U.S. trading partner, with the volume of trade dropping from 34% of the U.S. total in 1970 to about 27% in 1988. Latin American trade has also declined slightly in the same period. Japanese imports increased 16-fold, however, and therein lies much of the friction between the two countries, since exports increased only 10-fold.

An unexpected change, Hervey notes, has been the abrupt rise of Southeast Asia as a trading partner. Singapore, Hong Kong, Taiwan, and South Korea together have emerged as a new trading bloc that exceeds in volume the combined trade with the U.K. and West Germany. In addition, other nations in Southeast Asia, including Thailand, Indonesia, and the Philippines, steadily provide another 2 to 4% of U.S. trade.

At present, Eastern Europe and China are not particularly significant to the overall U.S. trade picture. However, they have increased their share of U.S. trade from 1% in 1970 to about 3% in 1989. Imports from Eastern Europe have only been about 0.5%, but Chinese imports were about 2.5% in 1989.

The net effect of these changes is that the traditional market sources for U.S. imports have displayed declines in market share, particularly Western Europe and Canada. Similarly, the relative importance of Western Europe as a market for U.S. goods has diminished. In contrast, Southeast Asia has dramatically appeared as a market for exports and a source of imports. Hervey notes about 75% of all U.S. trade is conducted with Canada, Western Europe, Japan, and Southeast Asia.

There are corresponding changes in the commodities that are traded. Agricultural products are less important than they used to be, as are foods, live animals, and intermediate products. Chemicals and machinery have about picked up the slack.

Commodity exports to Canada shifted in favor of transportation equipment. Machinery exports to Western Europe also improved, mostly business machines and computers. Agricultural and intermediate goods dropped in volume, and chemical exports remained stable. Chemicals and intermediates exported to Japan also increased to 11% in 1988, and professional and scientific equipment doubled to more than 3% at the same time.

The shift in commodity exports to Southeast Asia, says Hervey, is indicative of the economic involvement of the area. Food-related commodities dropped from 18% in 1970 to 6% in 1988, while chemicals rose from 8% to 12%, with most other categories rising to a lesser extent.

Hervey notes that exports to other countries are often mostly in the form of foods, reflecting endemic problems of growing population and lack of an industrial base. However, other observers suggest that some Latin American countries—for example, Mexico and Brazil—are developing industries as rapidly as economics permit.

The shift in import patterns has been more pronounced than those of export patterns. Canadian imports are tending toward goods with a higher added value and there is a corresponding drop in crude materials. The share in imported chemicals from Western Europe nearly doubled, to more than 10%, but most of the other commodities dropped. The exception was machinery, which rose from 19% to 26%.

Japanese imports also have displayed a shift toward higher added value items. Automobiles increased from 14% of total imports to 33% between 1970 and 1988. Even more dramatic was the increase in imports of office equipment and computers, from 24% of the total to 45% during the same period.

Almost the same pattern is displayed by commodities imported to Southeast Asia. Business equipment and electrical equipment imports rose from 12% to 37%. The most unusual feature of the Southeast Asian import trade was the increase in heavy capital equipment and transport equipment. The gain was about 4%.

All in all, U.S. export trading partners have changed position, with Western Europe and Canada heading the list, followed by Southeast Asia, Latin America, and Japan. The import roster is headed by Western Europe, followed by Japan, Canada, and Southeast Asia.

The big lesson in this analysis, says Hervey, is that Southeast Asia has emerged as a distinct trading bloc and should grow even more in the near future. Southeast Asia has inexpensive labor to which high-cost production will migrate and which will support a higher trade volume.

The geographical groupings Hervey outlines appear to be "natural" and easily definable. However, the events in Eastern Europe, as well as the forthcoming Western European economic integration in 1992 could change things again. One of the great question marks is still China. Anxiety is growing over the role that Hong Kong will play after its reintegration with China and over the corresponding "econo-brain" drain from Hong Kong, some of which already is in progress. Despite all the difficulties, the attractions of a potential market of 1.1 billion people in China keep world traders focused on the Pacific. This may also temper otherwise increasing economic interest in Eastern Europe. The European markets are essentially consumer markets. In China, there is also a consumer market. But before it can be exploited, the markets for a national industrial and infrastructural base must be satisfied.

Joseph Haggin

Various commodity classes show U.S. export/import shift

	Exports		Imports	
$ Billions	1988	1970	1988	1970
Manufactured goods	$22.75	$ 5.07	$ 61.78	$8.44
Machinery	88.43	11.37	117.38	5.28
Transport equipment	46.78	6.52	79.87	5.88
Chemicals	32.36	3.83	19.86	1.44
Petroleum products	3.52	0.47	38.39	2.76
Crude materials	24.99	4.60	13.24	3.32
Food and live animals	26.27	4.34	20.29	5.40
Miscellaneous manufactures	24.67	2.56	70.61	4.84
Other	50.53	3.79	20.74	2.60

Source: Federal Reserve Bank of Chicago

Chinese to expand fuel industry to meet needs

Development of the Chinese petrochemical industry has reached a plateau. Following five years of internal building and the trauma caused this past June by the government's suppression of demonstrators at Tiananmen Square, the industry is ready to consolidate its gains and proceed. But whether it will achieve higher plateaus is questioned by some foreign observers, who view the country's limited domestic crude oil reserves as a major problem.

What the Chinese themselves believe was outlined by Hou Fusheng, an official with China Petrochemical Corp. (SINOPEC) at the 1st International Symposium on Technology of Petroleum & Petrochemical Industry, held in Shanghai late last year. The picture he painted is of an industry that has acquired its basic form and is looking to modernize as quickly as possible.

SINOPEC has been in business since 1983, when it was established by the country's State Council. As a state-owned corporation, it now controls most of the petrochemical production and oil refining in China. According to Hou, Chinese oil refining capacity has grown to 120 million metric tons per year, with the actual production being about 102 million metric tons in 1988. This was an increase of 27% over 1983.

Chinese refiners have invested heavily in the "deep refining" processes necessary for processing heavy bottoms and residues. Hou says about 41% of Chinese crude is now deep processed, 28% in fluid catalytic crackers and another 13% in thermal crackers. This meets present demand for light products. To further upgrade motor fuel production, SINOPEC employs viscosity-breaking, makes methyl *tert*-butyl ether additives, and uses hydrogen fluoride alkylation and catalytic dewaxing.

The demand that is forecast in gasoline and diesel fuels during the next few years assumes a growth of 6.5 to 7% per year. The demand is expected to reflect the need for higher octanes and high-quality asphalts.

At present, China has an oil shortage. Intense efforts are being made to increase domestic oil production through exploration and discovery of new reserves. But foreign estimates suggest that, for economic reasons, the reserves, though potentially great, will not be developed at the rate desired.

Petrochemical production in recent years has grown sharply because of the commissioning of new plants. Between 1986 and 1987, three new ethylene plants started operating at Daqing, Quilu, and Yangzi, according to Hou. Each had a nominal capacity of 300,000 metric tons per year. Ammonia and urea production were similarly increased, with new plants at Zhenhai, Urumqi, and Ningxia. Each has a nominal capacity of 300,000 metric tons per year of ammonia and 520,000 metric tons per year of urea.

Hou says in the near future SINOPEC will be redirected, with emphasis placed on the production of resins, fibers, and rubber. Most important will be an increase in production of fertilizers to meet the government's goal of self-sufficiency in foods. Planned production of each of these commodities is supposed to increase "severalfold" by the end of the decade.

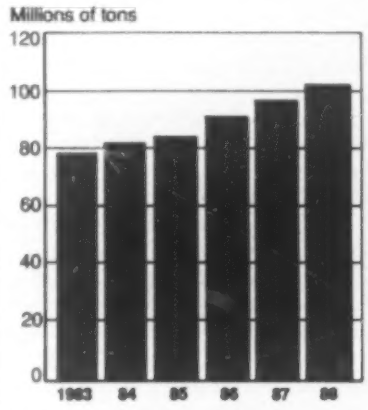
In outlining the expansion plans for the Chinese petrochemical industry, Hou acknowledged that a lot of cooperation will be required between Chinese and foreign companies. One optimistic sign, he says, is the renewal of discussions between a number of foreign lenders, most notably the World Bank.

In the area of refining, emphasis is being placed on further development of upgrading processes for heavy oils. Catalytic cracking, hydrocracking, coking, viscosity-breaking, and deasphalting will be particularly important. The goal is to maximize production of light distillates. Hou says that Chinese crudes have low metal contents, which simplifies processing. The Chinese want to produce gasoline research octane numbers (RONs) of 90 or more as soon as possible and to increase the amount of RON 97 gasoline as the top-of-the-line grade. Additives figure heavily in this effort.

At present, refineries are producing at about 90% of capacity, which means that any further increase in refinery production will require new refineries. Hou says when new refineries are built, they will probably be concentrated along the coast, possibly anticipating increased production from the offshore fields of the Luoxiao, Taiwan, and Jiangsu basins. He also notes that siting refineries inland will be done when and where other fields are found.

Joseph Haggin

Petroleum refining is up nearly 30% since 1983



Source: China Petroleum Corp.

Petrochemicals production has grown sharply

Metric tons, thousands	1988	1987	1986	1985	1984	1983
Ethylene	1111.0	818.9	586.6	555.1	551.1	555.9
Plastics	1026.0	726.0	555.1	487.3	485.2	482.4
Monomers	588.7	524.0	504.6	490.0	358.7	206.9
Fibers	347.9	326.9	313.5	306.4	241.2	174.0
Rubber	193.0	145.9	129.7	128.5	127.6	124.4

Source: China Petroleum Corp.

Bush's Science Adviser Discusses Declining Value of R&D Dollars

Despite apparent large increases to R&D funding, less "real" money is available for individual scientists, small science programs

By the numbers alone, it appears that federal funding for research and development has done nothing but rise steeply and steadily for the past 15 years, from $25.1 billion in fiscal 1976 to a projected $71.2 billion in fiscal 1991. Yet money for funding small science programs and individual investigators is in very short supply.

This paradox was one of the themes emerging from the American Association for the Advancement of Science's 15th annual colloquium on science and technology policy held in Washington, D.C., earlier this month.

Keynote speaker D. Allan Bromley reiterated his belief that President Bush's fiscal 1991 budget proposal (C&EN, Feb. 12, page 7) with its 7% increase for total R&D, 12% increase for nondefense R&D, and 8% increase for basic research is "an excellent budget for R&D in what is otherwise a very difficult budget year." However, he admits several areas of concern remain, with one very serious problem being the funding rate for grants at the National Institutes of Health and the National Science Foundation.

Bromley points out that during fiscal 1989, for the first time ever, the fraction of excellent, peer-reviewed new proposals that were actually funded by the two agencies fell below 30%. It is particularly unfortunate, he says, that this is occurring at a time when every effort is being made to draw more young people into scientific careers.

There are several reasons for the current plight of the individual investigator, Bromley says. One is that the rate of inflation for research in the physical and life sciences is rising at a faster rate than the consumer price index, and nonearmarked dollars for NSF and NIH have not kept pace. He also believes members of the scientific community are themselves in some ways responsible for the funding crunch. "For years," he says, "we argued for larger grants of longer duration." NSF and NIH heeded those arguments and in the process built up substantial "outyear mortgages" for themselves. A third factor is simple demographics. According to Bromley, "About 87% of all scientists and engineers who ever lived and worked in the U.S. are active today, while less than 4% of all citizens are still with us."

The effect of inflation of the research dollar was also noted by former AAAS executive officer William Carey, who said "the instinct to gloat over the elegant provisions for R&D in the new budget is rather abruptly suppressed if one looks carefully" at a table in the AAAS budget analysis that casts the R&D budget in terms of constant dollars. "If I can believe my eyes,"

Bromley: many reasons for plight

he says, "the message is that in constant dollar terms we will be nearly $10 billion shy of the real level-of-effort we had back in 1967. And for research, excluding development, we are precisely where we were, measured by funding effort, back in 1967."

That support for new research starts is at a near standstill despite "historic" new budget authority has not only left research universities in a state of shock, it has also had a del-

In real terms, federal R&D funds less now than in 1967

$ Billions	1991[a]	1990[a]	1989[b]	1980[b]	1972[b]	1967[b]
Development	$32.7	$31.9	$32.7	$33.3	$26.8	$42.1
Basic research	8.9	8.6	8.3	7.8	5.5	6.4
Applied research	7.9	7.7	7.7	7.5	9.0	10.4
R&D facilities	2.2	2.3	1.8	1.7	1.5	2.1
TOTAL R&D	$51.7	$50.5	$50.5	$50.3	$42.8	$61.0

Note: Constant 1982 dollars. a Estimate. b Actual. Source: "AAAS Report XV: Research & Development FY 1991"

eterious effect on the peer review system, Carey contends. "One hears [loud complaints] from exhausted panelists of reviewers who rate proposals on merit, only to realize the hopelessness of the whole business where, in the end, only one in four approved projects has a prayer of having a cheque arrive."

"The system is out of order," Carey concludes. "It was designed to work in a rising research economy, and nobody can make it work the way it is supposed to under steady-state or ration-coupon conditions."

Rodney W. Nichols, executive vice president of Rockefeller University, noted another effect of the funding crunch on individual investigators. In the halcyon days of real rises in research funding, individual researchers could look to many different agencies for support. That is no longer the case. Pluralism is out the door, Nichols says, when one agency has a monopoly on support of a certain kind of research as is now the case. A researcher has no real alternative when a proposal is turned down. NSF is no longer in any position to fulfill one of its original purposes—funding meritorious proposals that didn't quite fit in with the missions of other agencies.

There seem to be no easy solutions to these problems, particularly given the federal government's recent emphasis on megaprojects, such as the space station, the Strategic Defense Initiative, the Superconducting Super Collider, and the human genome mapping project. Carey suggests that if projects such as these are to be funded, and he sees a considerable amount of merit in some of them, then "we ought to be prepared to cough up the revenues to finance them as special initiatives that are not wrapped into the normal R&D budget. Unthinkable though it may be, there's no choice but to introduce extraordinary R&D goals to tax policy."

Bromley urges formation of a "constituency" for science, telling of the need for scientists to inform their individual Representatives and Senators of the need for the national investment in science and technology and the importance of supporting the university infrastructure.

Janice Long

House panel's clean air bill viewed favorably

Earlier this month the House Energy & Commerce Committee moved with unexpected alacrity and voted out a clean air bill just days after the full Senate had approved its version. Floor action on the committee's bill is expected in early May.

Since neither body had been able to accomplish this feat in the past 13 years (the last time the law was revised), hopes are now high that clean air legislation will become law this year. This all depends, of course, on the outcome of the House-Senate conference committee. The conference committee is expected to go to work early this summer. Its debate is likely to be contentious and drawn out.

The House panel was able to act as quickly as it did because its two chief adversaries—full committee chairman John D. Dingell (D.-Mich.) and health subcommittee chairman Henry A. Waxman (D.-Calif.)—and their allies were able to work out compromises. First a deal was worked out on tailpipe emissions, then followed compromises on smog in cities, toxic industrial emissions, and finally acid rain. Dingell doesn't expect "that any of these compromises are going to be changed on the House floor."

The only issue remaining in contention is alternative fuels. And during floor debate, Waxman has vowed to resurrect President Bush's call for automakers to build 1 million cars a year by 1997 able to run on methanol or other fuels.

The House committee bill is generally being better received than the Senate bill. Environmentalists believe its urban smog provisions are tighter than those in the Senate version. And industry lobbyists are pleased with the bill's provisions on second-round standards for toxic air pollutants. As Chemical Manufacturers Association spokesman Jeffrey C. Van says, "The House bill comes closer to what we think would make a good, effective law."

The two bills are surprisingly similar, but there are some key differences. Both bills have similar compliance schedules for attacking urban smog. However, the House committee bill would give states the right to control smaller sources of pollution, and the Environmental Protection Agency would be required to impose federal implementation plans when states fail to develop or implement their own adequate attainment plans.

The first-round tailpipe emission standards are nearly the same in both bills, but the Senate bill would phase in one model year earlier (1993 instead of 1994). Tougher second-round standards would go into effect in 2004 if 12 of the smoggiest cities are not in compliance in 2001, according to the Senate version. But in the House panel bill, similarly tough standards would go into effect unless vetoed by EPA. The agency would have to argue that the standards were not technologically feasible, cost effective, or necessary.

Both bills would require industry emitting toxic pollutants to install maximum achievable control technology within 10 years, though the House bill applies to more and smaller sources. They are most divergent in what to do about the remaining, or residual, risk. The Senate bill would require sources to reduce the risk of cancer to nearby residents to less than 1 in 10,000. The House committee bill would have Congress revisit the issue 10 years after enactment and then legislate based on an EPA study. Or Congress could have the law revert to the "ample margin of safety" language offered by President Bush in his clean air proposals.

The two bills offer similar approaches to acid rain control. Both would halve sulfur dioxide emissions from power plants by the year 2000 and would freeze them at that level. How to achieve this and also ease the burden on Midwestern utilities and coal miners is where the two bills diverge. The House panel bill would use a credits system as an incentive for utilities to install scrubbers. Those that did could get more credits and "bank" those early reduction credits for use later should they want to expand. Scrubbers would allow for continued use of high-sulfur coal, thus minimizing job losses in the coal fields.

Lois Ember

U.S. Can's aerosol can, plant at Derry, N.H.

Aerosol Product Innovation Fueled By Public Attitudes, Regulations

Susan J. Ainsworth, C&EN Houston

For those in the aerosol industry, there's no rest for the weary. Having recovered from a long battle with adversity in the late 1970s and early 1980s, aerosol producers and their suppliers enjoyed some healthy growth rates over the past several years. But now, because of mounting pressures from the public and from a variety of regulations, business is flattening out and growth is slowing again.

In the U.S., aerosol production was up 6.8% in 1988, according to the annual Pressurized Products Survey conducted by the Chemical Specialties Manufacturers Association (CSMA). However, next week when the 1989 survey is unveiled at CSMA's spring meeting in Chicago, some predict that it will show slower growth for aerosol products. "I think the survey will show growth of maybe a couple of percent if it is that much. One or 2% is more likely," predicts Jim Jandora, product manager for aerosols at U.S. Can Co., Oak Brook, Ill.

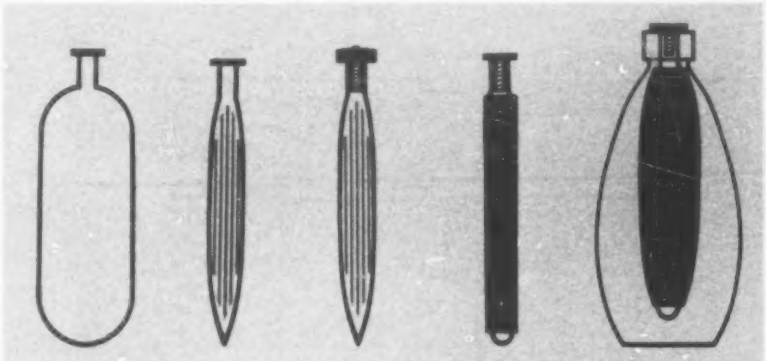
Likewise, in Western Europe, aerosol production has been slowing. In the U.K., one of the largest markets for aerosols in Western Europe, average annual growth hovered around 9% from 1981 through 1987, according to the British Aerosol Manufacturers' Association (BAMA). But growth in 1988 slowed to 1.6% and when the 1989 numbers come out, they will likely show that production declined 3 to 5%, according to BAMA director David Roberts.

Erosion of aerosol demand can be traced to several factors, but industry experts say environmental pressures from governing bodies and consumers top the list. "There's been a lot of undeserved bad publicity so I'd be very surprised if U.S. growth in 1989 turns out to be as high as it was in 1988," says Dick Frauenheim, president of Diversified Chemicals & Propellants Co. International, based in Channahon, Ill.

"Believe it or not, there are people out there that think that aerosols made in the U.S. still contain [chlorofluorocarbons]," despite the fact that they were banned with only a few exceptions in 1978, says Jandora. And there has been some un-

Nonaerosol package is gaining ground worldwide

The aerosol industry continues to suffer from negative publicity and a barrage of regulations. And as a result, some contend, marketers are eyeing other package forms so as to avoid these problems. One alternative package form that is gaining worldwide acceptance is the propellant-free Atmos container marketed by Exxel Container Inc., Somerset, N.J. "In some ways, we are a very big threat to the aerosol industry, but we realize that competing with it is going up against a giant," says Pamela J. Binder, Exxel's manager for marketing programs.



Source: Exxel Container Inc.

Atmos consists of an inner bottle of polyethylene terephthalate (PET), the same plastic used to make large soda bottles. The bottle is pleated into a narrow tube and fitted with a valve, inserted into a rubber sleeve, and placed in a larger container that can take on a variety of shapes and sizes to look just like any aerosol product. The contents are then injected into the bottle under pressure, expanding the bottle while stretching the rubber sleeve outward. The rubber's propensity to contract provides the pressure to release the product through the valve in a spray. "It's really quite a simple concept, but it also is unique," says Binder.

The container, which has been on the market since mid-1986, is catching on. Marketers in North America, Europe, and Japan are using Atmos to package dozens of products ranging from sun protection sprays to hair treatments and skin care products.

"Just within the past year, marketers that rely heavily on aerosols have begun major programs to examine alternatives due to the regulatory environment and consumer attitudes surrounding aerosols," says Peter G. Gould, president of Exxel. As a result of this trend, he says Exxel is "doing product experimentation with half the major aerosol users right now. That does not mean they all will adopt our system," but it has boosted the company's growth projections for Atmos almost overnight.

Still, the system may not compete with the aerosol in every product category. One industry source notes that Atmos has its drawbacks: "It sprays coarse and wet and some product ingredients are not compatible with the plastic packaging." Gould concedes that the container is not compatible with all solvents and product ingredients. For example, Atmos would not be a good package for oven cleaners or disinfectants, although it works well with a broad range of personal care products, he says. And he adds that Atmos' spray is wetter than aerosols, "because it is spraying pure product without the 10 to 30% gas per unit time sprayed from an aerosol."

There may be a glitch, too, in Exxel's campaign to promote Atmos as an environmentally friendly alternative to the aerosol, says another industry source. "While these packages don't rely on propellants, they do add to the landfill problem. Unlike metal aerosol cans, the plastics they are made from are not recyclable."

founded bad publicity about the issue surrounding volatile organic compounds (VOC), which started in California, according to Frauenheim. As a result of this kind of publicity, he anticipates "maybe some reluctance on the part of marketers to introduce new aerosol products," which will also limit growth.

In Europe, where Diversified CPC has become a major propellant supplier, misinformation and bad publicity are also taking their toll, especially in West Germany, where that sentiment is particularly strong, notes Frauenheim. Roberts agrees: Growth in the Western European market for aerosols has slowed, "because of the change away from CFCs and the adverse publicity," that that switch has attracted.

But aside from that factor, when the numbers are out, growth in 1989 is expected to have declined, partly because growth was unusually high in 1988, says Frauenheim. What took place in 1989 was normal market growth, Jandora contends. Last year was a "wait and see" period without the flurry of introductions that affected the market the way they did in 1988, he adds. "The market generally needs time for products to settle. Not everybody launches at the same time," says Jandora. "If the introductions had been spread out, the industry would have seen a more even distribution of growth. It's just a function of timing."

These factors, along with the slowing economy, should have had some negative effect on overall aerosol volume in 1989, says Frauenheim. "The U.S. economy in 1989 did not perform as well as we hoped it would. There was little inflation and no recession, but there was not a heck of a lot of growth either," he adds. And in the U.K., the slowdown in the aerosol sector can be attributed to "the turndown in consumer spending probably more than anything else," says BAMA's Roberts.

Still, on a world scale aerosol production is growing, even if it is growing at a slower pace. Some contend that the convenience of the aerosol will continue to be its saving grace. How have aerosols managed to weather the storms of controversy and massive reformulation over many years? "Because aerosols are safe and convenient, quick and clean, spill-proof, kid-proof, and there are certain applications that require the aerosol form," says CSMA president Ralph Engel. "It's probably the single most innovative package in the world and it's a package of choice of the consumer," he adds. For these reasons, aerosol industry players contend, the aerosol industry is here to stay.

That's good news for the chemical industry. The aerosol industry is a significant purchaser of chemical products—above and beyond the chemical contents of the products put into aerosol cans. For example, it consumes 293 million lb per year of hydrocarbon propellants, according to propellant supplier Aeropres, Shreveport, La. Aerosol hair sprays have boosted consumption of ethanol significantly over the past two decades. The industry sometimes needs high-performance linings for their cans. And many of the parts of an aerosol container are plastic, making these packages in turn a good customer of the chemical industry. Thus, the continued growth of the aerosol industry benefits the chemical industry as well.

Indeed, when CSMA's survey is unveiled next week, 1989 may well show up as the seventh straight year of real growth in units for the U.S. aerosol industry. According to the most recent CSMA annual Pressurized Product Survey, an estimated 2.91 billion aerosol container units were filled in 1988, up from 2.72 billion in 1987.

Citing the 1988 CSMA survey, Dan Minogue, chairman of the CSMA Product Survey Committee and vice president of sales at Precision Valve of Yonkers, N.Y., attributed the increase in 1988 to a number of factors. Some of that growth came from new product launches in the antiperspirant and hair spray areas, along with increased demand for hair sprays for today's changing hairstyles. In 1988 personal products were the largest U.S. category of aerosols, making up more than 37% of the total containers filled—some 1.1 billion units. And hair sprays made up the largest single product category broken out in the survey. The domination of personal products and hair sprays will likely continue in the 1989 survey, say aerosol industry players.

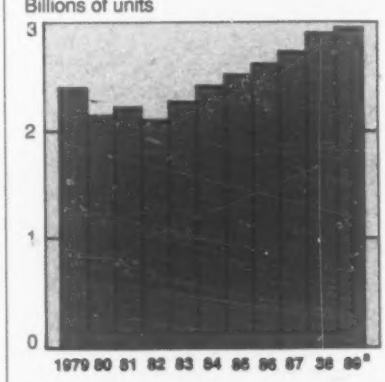
"Hair sprays have been a very large growth market for us," notes U.S. Can's Jandora. He points out that growth in that segment is a function of style, which currently calls for a very stiff hold. Back in the early to mid-1980s when mousses were popular, "we saw some softening in the hair spray market, but now hair sprays are on an upside," says Jandora. "The combination of hair spray and mousses was very big last year," says Frauenheim. "That was surprising because a lot of people thought that when the mousse came out it would replace part of the hair spray market." Instead, he notes, a teenager might use a mousse and then hold the style with a spray. "So the mousse has turned out to be a good combination product rather than a replacement for hair spray."

Growth for the whole hair fixative market, including retail and salon segments, shows no sign of slowing, according to Frank Nowak, marketing manager for cosmetic polymers at National Starch & Chemical. The company produces a broad line of resins used in hair care products worldwide.

In Europe, hair products also comprise a large segment of the aerosol industry as do deodorants and antiperspirants. But growth in sales of mousses for the hair and body has slowed, according to Fiona Leinster-Evans, marketing assistant for CMB Aerosols, Pangbourne, U.K., an arm of CMB Packaging, which was formed in late 1988 by the merger of U.K.'s Metal Box and France's Carnaud. "Hair mousse has become a commodity product now and is selling in larger packs," whereas before it was sold in "luxury packs," she adds. Buoying European aerosol growth in hair care has been a proliferation of products including spritzes, gel spray, hair cream, hair wax, shine spray, and conditioning spray, says Leinster-Evans.

And perhaps a good sign for continued strength for aerosols in the antiperspirant market in 1990 is

Production of aerosol units continued climb in U.S. . . .



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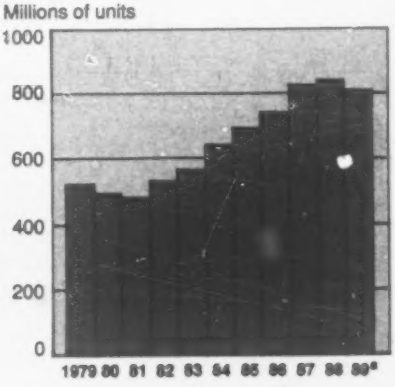


a C&EN estimate.
Sources: Chemical Specialties Manufacturers Association, British Aerosol Manufacturers' Association

Helene Curtis Co.'s introduction early this year of its Degree antiperspirant and deodorant product. The Chicago-based personal care marketer is selling the product in solid and roll-on forms as well as in an aerosol package.

Says one industry source of the launch: "It's interesting that a company would introduce an aerosol antiperspirant with California poised to issue regulations that could affect its sale. That's a very bullish move from an aerosol standpoint." In response, says Andrea Saia, group brand manager for Degree: "Aerosols comprise about 20% of the antiperspirant market segment, and we want to capitalize on that segment." "Not surprisingly," she adds, "consumer demand for aerosol antiperspirants has been stable over the past couple of years, because they are the most convenient and hygienic form."

And in Europe, deodorant aerosols have continued to enjoy success. For instance, in the U.K., aerosol deodorants account for 65% of all such products, says Leinster-Evans. Meanwhile, pump deodorants have only 1% of the market.

Demographic changes with an increasingly aging population is resulting in a new group of consumers, notes Leinster-Evans. Demand for new products aimed at this market could boost growth in personal care aerosols. And a growing market for personal care products for men could have a similar effect.

A proliferation in eye care products also helped buoy growth in aerosols in the U.S. in 1988, says Minogue. For example, saline solutions have been packaged in spill-proof, contamination-proof aerosol cans for some time now. And the saline solution niche has created new demand for aluminum cans, which have been losing out over tinplate cans in the U.S. recently, notes one source. "If you put saltwater in a tinplate can it will just about decompose on you," the source adds.

Another factor that lifted 1988 growth for aerosols was continued growth in the automotive and industrial areas as professionals and do-it-yourselfers use aerosol products, says Minogue. One interesting innovation in the auto segment is the introduction of aerosol kits sold to auto dealers to use to clean clogged fuel injectors in new cars, notes Frauenheim.

Palletized loads of empty aerosol containers at U.S. Can's Racine, Wis., plant await

In trying to assess how aerosols might perform in 1990, Jandora points out that aerosol growth could depend somewhat on the weather, strange as it may sound. "The aerosol industry is very closely tied to mother nature," he says. For example, a frigid winter means growth in the use of aerosols such as air fresheners, deicers, carburetor cleaners, and sprays for frozen locks. On the other hand, a wet spring and hot summer means more pests for consumers, who tend to buy more aerosol insect repellants.

The Lyme disease scare last year fueled the insecticide segment of the aerosol market, he notes. "And when we had that hot summer in the U.S. recently," he adds, "people tended to use more personal care aerosol products such as antiperspirants and hairsprays."

But perhaps more than any other factor, the fate of the aerosol industry rests largely on future regulation. Indeed, regulation has had a major role in shaping the U.S. industry to date.

For example, when CFCs were banned in the late 1970s, the industry was forced to reformulate its products and start a still-continuing public relations campaign aimed at educating the public about how aerosols affect the environment.

Research done in the 1970s showed that CFCs are not degraded under normal conditions, but persist to react with stratospheric ozone, breaking it down and destroying part of the ozone shield that surrounds Earth. The result is an increase in the amount of ultraviolet radiation reaching Earth's surface. The most obvious source of free CFCs was aerosol propellants, which were vulnerable because they were deemed convenience products that the consumer really didn't need. So in 1978, the Environmental Protection Agency and the Food & Drug Administration banned all fully halogenated fluorocarbons as propellants in nonessential aerosol uses, which make up about 98% of all aerosols filled in the U.S.

This legislation created a public controversy in the U.S. Consumers believed that all aerosols were contributing to the depletion of the ozone layer, even though more than half of the industry used hydrocarbons, not CFCs, as propellants. And, amazingly, more than 10 years after the ban, "there's an unfortunate misconception that aerosols are damaging to the stratospheric ozone layer. The industry [in the U.S.] now relies heavily on hydrocarbon propellants, which don't damage it at all," says Harry McCain, technical and safety director at propellant supplier Aeropres and vice president of the National Aerosol Association (NAA).

shipment to fillers

Ironically, it may be the publicity of efforts to further reduce CFCs production worldwide that has fueled public controversy about aerosols. "With the CFC ozone issue blowing up again relative to the [Montreal Protocol on Substances That Deplete the Ozone Layer] and reduction of CFCs in a variety of product forms, the media seized the opportunity to pound the same old message into the consumer. So we have a story to tell all over again," says CSMA's Engel.

The Montreal protocol, which became effective in January 1989, calls for a 20% reduction in production of CFCs by 1993 and a 50% reduction by 1998, based on 1986 levels. And the word is that that schedule may be accelerated when the parties bound by the international treaty meet in London in June to amend it. Most, if not all, parties agree that there is a need to eliminate CFCs by 2000.

These measures affect the shrinking volume of CFCs still used as propellants in other countries and the exempted aerosol applications in the U.S. More significantly, however, they are aimed at CFCs used in other applications such as air-conditioning, refrigeration, and foam blowing. In reporting about this accord, "the news media gave the erroneous implication that all aerosols produced in the U.S. still contain CFCs. Except for a few product categories, they do not, but the public simply didn't hear it that way," Frauenheim says.

Controversy is also brewing in Europe, where CFCs have been phased out more recently. For example, at the end of 1989, aerosol producers in the U.K. voluntarily decided to stop using CFCs. As in the U.S., the exception is vital medical and industrial needs, which account for about 10% of all aerosols in the U.K.

The European Community has issued recommendations calling for a swifter CFC phaseout than called for by the Montreal protocol. The commission is calling for reduction in CFC consumption by 90% of what it was in 1976 by the end of 1990. "There's a strong compulsion for BAMA members and the whole industry to adopt the commission's recommendation. My guess is that Europe will meet the EC target," says BAMA's Roberts.

Perhaps it is pressure from the European public that is speeding the change. "The erosion of the ozone layer has turned the consumer away from aerosol products with CFC propellants. This, in turn, has caused a decline in the production of aerosol cans," in Europe, says a study on the Cosmetics & Toiletries Packaging Market in Western Europe put out in the fall of 1989 by Frost & Sullivan, New York City. "Aerosol can production in West Germany dipped by about 12 to 15% last year as they were reformulating away from CFCs. Negative publicity hit that country the hardest; I don't think any of the other European markets suffered to that degree," says one industry source. But for his part, BAMA's Roberts says he is not witnessing a decline in can production in the U.K.

To be sure, there are many factors currently at work to ensure a speedy end to CFC production worldwide. One such factor—a new U.S. federal excise tax on stocks of CFCs that went into effect on the first of this month—may contribute to that effort. Manufacturers must pay $1.37 in tax for every pound of CFCs they make in 1990, escalating to $1.67 in 1992 and $2.65 in 1993. Importers must also pay tax on CFCs and all products that are made with CFCs that they bring into the U.S. The tax will essentially double the price of CFCs. For example, Du Pont sells its bulk CFCs for roughly $1.00 per lb. "As for how this new tax will affect aerosols, my impression is that producers in exempted categories will reformulate with a cheaper CFC substitute if they possibly can. But you have to assume that the reason the government exempted these applications is that they couldn't readily use some other propellant," says Tony Vogelsberg, environmental manager for Freon products at Du Pont.

The "essential" aerosol applications that are exempted from the CFC ban include medical products such as contraceptive foams and bronchial dilators, products used by the Department of Defense, food products containing F-115, certain uses in electronic/electrical and aviation industries, and certain pesticide uses. But Vogelsberg points out that this category only represents about 30 million lb of CFCs, or about 4% of the total U.S. CFC market. And, he predicts, by the year 2000 there will not be any CFCs in any product, referring to the likelihood that the Montreal protocol will increase the stringency of its phaseout program. "They'll be history. Aerosol producers will have no choice but to go to alternative products or alternative approaches," Vogelsberg adds.

Looming on the horizon has been another issue that the aerosol industry fears could take on the same weight and magnitude that the CFC issue had. The biggest perceived threat currently to the livelihood of the aerosol industry is the clean air issue, according to CSMA's Engel. "The challenge is to make the regulators and legislators understand that we can take drastic actions by getting rid of all consumer products with the wrong steps and thus put industries out of business without doing much for clean air. Or we can take the time to determine what steps we can take while maintaining commercially and technologically viable products," he says.

Although clean air legislative activity is taking place independently on federal and state government levels, proposals by the California Air Resource Board (CARB) have the

most immediate repercussions and potential long-range impact, according to Albert L. Pellini, chairman of the board of CSMA and vice president of sales and marketing at Advanced Monobloc Corp. of Chappaqua, N.Y. CARB is considering legislation to control the use of hydrocarbon aerosol propellants—propane, isobutane, and *n*-butane—as part of its efforts to control the formation of smog (or ambient ozone) from VOC emissions. Fortunately for some aerosol producers, the amended California Clean Air Act prohibits CARB from adopting any regulations unless the regulations are technologically and commercially feasible and necessary. But these criteria apply only to consumer products.

For many years the industry as a whole has been trying to tell regulators that they may be barking up the wrong tree when it comes to trying to reduce smog problems in major U.S. cities. "If we stopped making personal care products and banned every aerosol on the face of the Earth, the fact is that it would probably not improve ambient ozone or smog conditions one iota," says Aeropres' McCain.

In a statement on aerosols and VOCs, NAA says: "VOCs and photochemically reactive compounds (PROC)—propane, isobutane, and *n*-butane—as utilized in propellant systems for aerosol packages simply do not make any significant contribution to atmospheric ozone pollution." NAA bases that contention on four main points.

First, "aerosol propellants are an infinitesimal part of the VOC/PROC emissions in the U.S," says NAA. Second, "aerosol propellants present a significantly lower order of chemical reactivity which does not influence or contribute to smog production," it adds.

Third, "both quantity and usage patterns do not allow VOC/PROCs from aerosols to impact air quality," NAA asserts. For example, "with a shave cream or a tub and tile cleaner, the hydrocarbon propellant is mixed with the product and tends to be washed down the drain with the product to be biodegraded. So these types of products do not affect smog formation," Frauenheim explains. Fourth, "any reduction or alterations in aerosols could result in alternative packaging forms which may have a negative impact on air quality," says NAA. One misconception, for instance, is that pump sprays represent a more environmentally friendly alternative to aerosols. But when it comes to VOCs, pump hair sprays, for example, rely on solvents such as ethanol, which is a much more reactive VOC than hydrocarbon propellants are, according to Frauenheim. And Aeropres' McCain asserts: "Hydrocarbon propellants are less tropospheric ozone-forming than ethanol—and many other VOCs used in formulations—by a factor of 50%."

To get these points across, NAA has formed a group to submit new information to CARB in an attempt to correct erroneous data on hydrocarbon propellants, says McCain. He laments that EPA is borrowing misinformation from CARB and adopting the same attitudes. "So we have a significant amount of reeducation to do to perpetuate the aerosol industry."

For its part, the CSMA Special Air Quality Committee has been "working for more than five years to provide California regulators with technical and economic evidence of the minimal contribution to the formation of smog from VOC emissions from underarm products" says Pellini. "We are making significant headway, too, not just with CARB, but with New York, New Jersey, Texas, and federally," adds Engel.

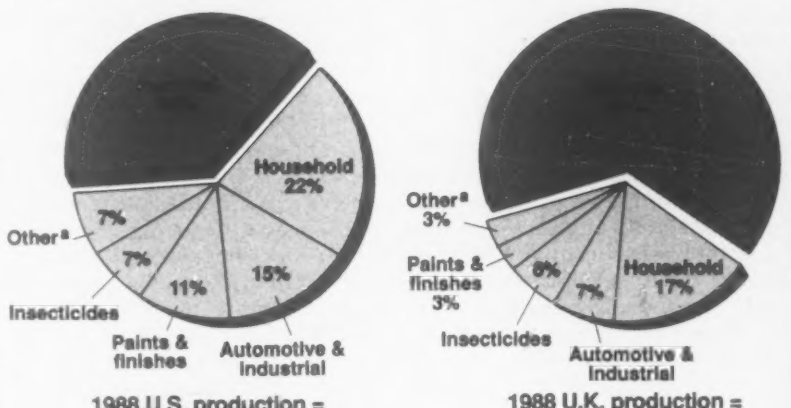
For example, CSMA says it was effective in promoting a realistic modification of New York Department of Environmental Conservation's proposal to reduce VOCs by 25% in insecticides, disinfectants, and air fresheners. As adopted, the proposal requires a four-year study of the environmental and cost impacts and feasibility of alternatives for reducing VOC emissions in those products, while maintaining product efficacy. A CSMA consortium of nearly 100 companies is conducting the study.

In Europe, "the VOC issue is not as strong as it is in the U.S. yet," says BAMA's Roberts. "But we anticipate that it will be in the not too distant future. What happens in the U.S. is likely to happen in our country only a little while afterwards."

Warehouse storage has long been a troublesome issue to the aerosol industry. "But this is now a concern to which the industry can respond technologically and has done so," says Aeropres' McCain. Basically, through CSMA efforts, the aerosol industry was able to modify guidelines of the National Fire Protection Association (NFPA) to make them "more livable for the industry," while preserving safety, says Frauenheim.

CSMA approached NFPA's Standards Council to suggest that its Code 30, which covers class IA flam-

Personal products dominate U.S. and U.K. aerosol industry



a Includes food products, veterinary and animal products, and miscellaneous categories.
Sources: Chemical Specialties Manufacturers Association, British Aerosol Manufacturers' Association

mable liquids, be modified to include a separate section pertaining to aerosols. At that point, "aerosols were treated more strictly than gasoline, because of the flammability profile of hydrocarbons," says David L. Fredrickson, chairman of the CSMA Aerosol Fire Testing subcommittee and senior chemical safety information administrator at S.C. Johnson Wax, Racine, Wis. "We needed to prove that while all aerosols act differently, they are not as flammable as their respective components, because they are blended and stored in metal cans, etc."

After spending 10 years and about $2 million, CSMA was able to demonstrate to NFPA that some guidelines were stricter than they needed to be. As part of that effort, CSMA and the National Paint & Coatings Association provided funding and expertise to conduct fire tests at a Factory Mutual Insurance research facility in West Glocester, R.I.

And under a NFPA Research Foundation program led by Factory Mutual, CSMA helped to develop new warehouse sprinkler technology. Compared with conventional systems, the early suppression, fast response technology is designed to "put out fires rather than just control them until the Fire Department arrives on the scene," adds Fredrickson.

"In any situation you can get to the point where something is regulated to be 100% safe, but you have to weigh the cost of those measures against the risks of something going wrong," says Fredrickson. He believes that the industry was successful in modifying these NFPA guidelines because the effort brought together professionals on all sides of the issue—insurance, industry, fire service, and wholesalers. And in coming up with a final document, NFPA considered, and adopted some, of more than 300 public comments, many from the aerosol industry. "Warehouse storage is a nonissue for the aerosol industry now and it is a success story for CSMA as well," says Engel.

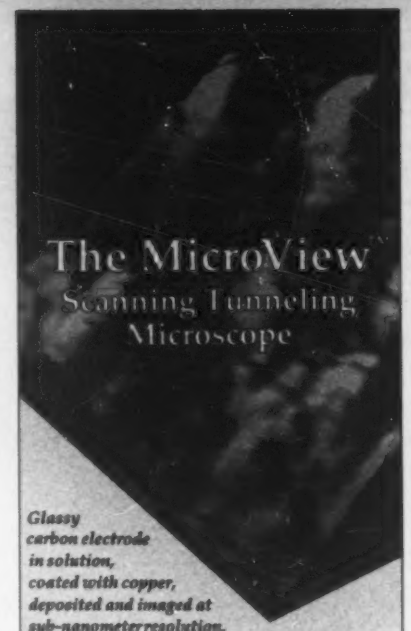
As in the past, regulations will likely be a major force in shaping the aerosol industry. Notably, the controversy over CFCs gave the final push to a switch to hydrocarbons. At the time of the controversy, hydrocarbons already were being used in some 55% of all aerosols filled because they were less expensive than fluorocarbons.

And since that shift, hydrocarbons have been the mainstay of the industry. The major suppliers of hydrocarbon propellants are Phillips 66 (Bartlesville, Okla.), Diversified CPC, and Aeropres. Diversified CPC bills itself as the world's largest supplier of hydrocarbon propellants now that it is operating its Krefeld, West Germany, plant, with its joint-venture partner Klockner & Co.

Growth of hydrocarbon propellants in the U.S. is hovering around 6% per year for the 1989–90 period, outpacing the aerosol industry itself, according to Aeropres. For its part, Diversified CPC's Frauenheim says his company's business is growing faster than the aerosol industry overall both domestically and in Europe, mostly because "we've developed more market share in Europe and in the U.S. Plus, we've been very active in exporting our products to Puerto Rico, the British West Indies, and the Bahamas." The mousse and new piston technology—which allows the dispensing of very viscous compounds via aerosols—have been growth areas for Diversified CPC, he says.

And because Diversified CPC was able to be in the right place at the right time with its Krefeld plant, it has been able to take advantage of growth in hydrocarbon propellants in Europe. Fluorocarbons were still being used widely when the Krefeld plant was being built, so the company was in place "to take advantage of the switch away from CFCs."

In addition, when Diversified CPC built the plant, it was the most modern hydrocarbon propellants plant built in many years. That helped the company attract customers in the high-value product categories—cosmetics and colognes, for example. "When we were just completing our plant in 1986, we anticipated that we'd be able to tap a certain amount of new growth each year as the new guy on the block. But we've grown dramatically every year and we are well ahead of schedule as far as our planned sales for Europe," says Frauenheim.



Glassy carbon electrode in solution, coated with copper, deposited and imaged at sub-nanometer resolution.

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A decade ago, hydrocarbon propellants took center stage because they, unlike CFCs, did not cause damage to the ozone layer. And hydrocarbon propellants have another thing going for them: They cost only cents per pound compared with dollars per pound for other alternatives. But for one reason—flammability—they are not safe for every application and they are expensive to store.

That's where hydrochlorofluorocarbons (HCFCs) came into the market, for what will likely turn out to be a short visit. These propellants generally are less flammable than hydrocarbons, and they have ozone depletion potentials of only about one twentieth of CFCs. Because these compounds contain hydrogen, they are less stable so that they break down in the lower atmosphere before reaching the stratospheric ozone layer. By mixing HCFCs and hydrocarbons, for example, one gets a formulation that is less flammable than hydrocarbons alone and more ozone-friendly than CFCs. In December 1982, with these benefits among the selling points, Du Pont introduced a new line of propellants under the Dymel trademark. The line included HCFC products 22 and 152. But with renewed interest in the elimination of CFCs and other halons that threaten the ozone layer, HCFCs also are coming under fire.

"When we introduced Dymel it was largely a program for us to take advantage of the 1978 CFC regulations," notes Don Dunn, market manager for aerosols at Du Pont. While the company found market penetration slow at first, business began to pick up in early 1986 "and there appeared to be some opportunity for us in Dymel." But shortly afterward, the ozone controversy was reactivated and "it really hit hard," he adds. Clearly, now there's a desire to further reduce CFCs by the middle of the next century and to get rid of mimimal ozone depleters such as HCFCs as well, he points out. "So, what we viewed as an opportunity for growth of HCFCs like 22 has largely disappeared as HCFCs are no longer viewed as environmentally acceptable."

One last bastion of opportunity for HCFCs in aerosols is in replacement of CFCs for government-exempted "essential uses," notes Dunn. In exempted applications where CFC-12 is used for nonflammability reasons, there is already significant conversion to HCFC-22, he adds. However, he does not see short-term substitution options for products that now rely on CFC-113 or for pharmaceutical applications. "Reformulating medical aerosols requires much toxicology research and redevelopment, so that is one area that will probably continue to use CFCs until late this century."

Because HCFCs are still ozone depleters, "they are considered only bridge compounds to long-term HFCs that do not contain chlorine," says Dunn. "Getting to HCFCs was one step. Getting to HFCs is a lot more difficult, because it requires a much more complex manufacturing process," he explains.

ICI and Du Pont are among the companies that have come up with HFCs and are poised to produce them on a commercial scale. Dunn anticipates that it will be the mid-1990s before the industry is ready to supply the larger markets.

Engel: aerosol is package of choice

According to ICI Americas chairman Ben Lochtenberg, HFC-134a has potential in the aerosol industry, but it will be considered after the larger markets, when ICI's plants in Runcorn, U.K., and St. Gabriel, La., come on stream over the next two years.

Although Du Pont has lowered its expectations for the HCFC compounds in its Dymel line, its Dymel A dimethyl ether (DME) propellant shows promise. The major selling point for this propellant is its solubility in water, which is cheaper and more appealing from a VOC standpoint.

Du Pont brought DME to the marketplace in 1986 using an existing facility, notes Dunn. "And so far, growth in the U.S. has been slow to say the least," he says. "In contrast, DME has found good acceptance in Europe where growth has been quite rapid."

The reason for Du Pont's DME success in Europe may be another case of being in the right place at the right time. Dunn explains that DME became commercially available at the time that Europe was reformulating away from CFCs. In contrast, when the U.S. converted its

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aerosol formulations, DME was not an option. With all that reformulation behind them, few U.S. companies are willing to adopt a new propellant, which is generally more expensive than hydrocarbons, Dunn conjectures.

DME is finding wide acceptance in Europe in the hair care market for higher priced, high-performance salon products. For example, DME can be used in formulating water-based hairsprays, which are becoming increasingly popular, according to Dunn. To further capitalize on this market, Du Pont subsidiary Conoco is building a new DME plant at its Humber refinery in northeast England, with completion set for the end of this year. Du Pont already has a major production unit for DME near Charleston, W.Va.

And the DME market in the U.S. is looking brighter. Demand could rise in the U.S. and elsewhere if expected amendments to the Montreal protocol include controls on methyl chloroform, notes Dunn. "In the absence of another nonflammable chlorinated solvent, formulators may start looking at water-based systems, he says. And, depending on how the VOC regulation shakes out, DME may become more popular for its compatibility with water, notes National Starch's Nowak.

Indeed, environmental pressures are limiting the kinds of propellants that marketers can choose from in formulating their products. That fact has given life to nonaerosol packages such as the Atmos container marketed by Exxel Container Inc.

But some in the industry say the propellantless-pump is not regaining the strength it had in the U.S. during the last wave of public awareness over the CFC issue. Basically, consumers did not like the wet and heavy sprays from pumps and perhaps they haven't forgotten the experience, suggests one industry source. "In the late '70s, we saw consumers go to the pump, and most of them came running back to the aerosol, including my daughters," says Frauenheim.

In Europe, demand for pumps seems to be poor, too. Hairsprays in pump packs have had some success. Clairol Finale has been the most successful pump hairspray and has over 3% of the market, says CMB's Leinster-Evans. However, she adds: "Early research from West Germany indicates that repeat purchases of pumps are poor and the aerosol industry is regaining sales lost to pumps."

Aerosol manufacturers are also focusing R&D on developing an aerosol system that will enable compressed gases to be used as more effective propellants, she says. For example, late last year CMB launched its Horizon package, which is a new twist on the compressed gas aerosol. Through this package, CMB claims to have solved three problems with conventional compressed gas packages: variable

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flow, wet spray, and the lateral effect, the lack of spray when a can is held at certain angles.

In another R&D push, some companies including CMB are involved in extending the utility of the bag-in-the-can, which has been around for many years. In this system, product sits in the bag separate from, but completely surrounded by, propellant. Because the propellant does not mix with the ingredients, it is possible to dispense viscous formulations such as caulk, gels, and pastes. Initially, nylon was the only choice of bag material. But now CMB is offering bags made of five-layer laminated plastic and low-density polyethylene, which it says widen the range of items that can be packaged in this manner.

The trend toward the high-style, slimline can, which had its birth in Europe, continues to pick up pace in the U.S. This can features a neck that is tapered just a bit, so that when the cap is put on, it makes a smooth line from top to bottom. There is no ridge where cap meets can.

"The necked-in can has come into the aerosol industry in waves," says U.S. Can's Jandora. First, the personal care marketers adopted the style, which is more fashion-oriented, he says. "Now, we are starting to see them in household products such as glass cleaners and furniture polishes."

Indeed, in the 1990s Europe is destined to become an even greater force in the worldwide aerosol business. For one, the formation of a single, harmonized European market by the end of 1992 could make the U.K., Europe's largest aerosol market, even more dominant. For the U.K., 1992 likely will bring "a larger export market initially," predicts BAMA's Roberts. "We will have to face imports, but because the U.K. market is the largest in Europe, we should well more than compensate with exports. We should be able to play that [dominance] very strongly," he adds.

And Europe, with its collective strength could be a greater threat to the U.S. aerosol industry. Engel points out that while Europe is working toward a more unified marketing system, the U.S. is "doing just the opposite." Europe is breaking down barriers and harmonizing rules to allow for the easy sale and transportation of goods across borders. "We, on the other hand, in what was originally called new federalism, have shifted to a state-by-state regulatory approach. The result is a patchwork quilt of regulations that are going to break down the system of distribution in this country and make us noncompetitive."

Formulation of new aerosol and cosmetic products is focus of National Starch & Chemical's Bridgewater, N.J., cosmetics lab

Because some consumer product marketers produce their products at plants that serve more than one state, a change in one state's requirements could have a significant impact on the total market. For example, if a company must reformulate its products to meet California VOC regulations, it then has to decide whether to reformulate all of its products or produce separate products for that one state. "It becomes a question of whether a company is able to condition itself for that geographical market alone," says Du Pont's Dunn.

For the U.S. to remain competitive in the world, "we need to realize that there are appropriate times for the federal government to preempt state activity," Engel says, adding: "We have such a marketing edge in the world, what a shame to shoot that down and let the world take us over."

Some industry observers expect that Eastern Europe may also become a magnet for U.S. aerosol investments in the 1990s. Changes in this part of the world may well open the door to new growth opportunities for western companies. Diversified's Frauenheim points out that Eastern European companies currently make some aerosols, but most of the processes are based on older technologies.

"We had a booth at the International Aerosol Congress in Nice, France, last fall and I was amazed at the number of representatives from Eastern European companies that stopped and showed a lot of interest in aerosol manufacturing and hydrocarbon propellants, in particular," Frauenheim says. But while the demand for westerners' range of products and technologies exists, one of the drawbacks to investment in this part of the world is obviously their currency, he says.

Separately, some industry observers anticipate that the 1990s will be another decade of reformulation. National Starch's Nowak anticipates that demand for "natural" raw materials will intensify because of public concerns over animal rights and the environment. This could mean a trend toward more water-based formulations, for example.

"Reformulation of aerosols will occur to allow for the aerosol package to exist," says Engel. "We have an obligation to do our fair share, but only our fair share, to clean up the air and that will undoubtedly require some aerosol reformulation." The aerosol has been a package under siege for many years, but it continues to weather these storms simply because the consumer wants it. And looking into the next decade, Engel adds: "The aerosol industry will continue to grow and consumers can be confident that they are using a package consistent with the environment." □